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# Study of the leaf epidermis in some Egyptian taxa of *Fagonia* L. by SEM

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## ABSTRACT

Leaf epidermis structure of 13 *Fagonia* taxa has been studied by Light microscope (LM) and Scanning electron microscope (SEM). Anomocytic stomata type, different trichomes features, cuticular ornamentation and stomatal levels are determined. Results allow clear definition and identification of the taxa. Among all the studied characters, cuticle ornamentation and trichomes features were noticeable to characterize each taxa of *Fagonia.*

The present studies recorded about 27 different trichomes,18 glandular, 8 non-glandular and one special structure trichome. Some taxa were free from glandular trichomes and others were free from non-glandular trichome beside the taxa which have the two types of the trichomes. Three types of trichome ornamentation are recorded in these work; smooth, papillose and warty. The cuticular ornamentation recorded three types' favulariate, straiated and wrinked. On the basis of observation we created a key for distinguishing *Fagonia* taxa.

**Key wards**: Trichomes feature and cuticular ornamentation.

## 1. INTRODUCTION

The genus Fagonia belongs to family Zygophyllaceae containing about 40 species of dwarf shrubs or perennial herbs. In Egypt there are 18 species according to (El-Hadidi 1966) and (Tackholm 1974), while (Boulous 2000) recorded 15 species and 6 varieties.

Lot of studies had been done on the Fagonia species based on Macro & Micro-morphological characters and phylogenetic studies such as these of (Ozenda and Quezel 1957), (Porter 1963), (El-Hadidi 1966), (El-Hadidi 1972, 1974 and 1978), (Ahmed 1991), (Ahmed and Khafagi 1997), (Khafagi 2004), (Beier et.al., 2004), (Beier 2005), (Alam 2011) and (Abdel Khalik and Hassan 2012).

Trichomes occur in plants in a great variety of forms, and are sometimes very complex structurally. The micromorphological characteristics of foliar trichomes have played an important role in plant systematics, especially of particular groups at the generic and specific levels (Hardin1979). Such type of studies in the field has fascinated plant morphologists and systematists towards the diversity of trichome features (Yan-Ming & Ru-Wen 1993). The trichome types are not only useful in the identification of the two species, but also their corresponding parts, thus being important in pharmacognosy, archaeobotany, paleobotany and agronomy (Rao and Ramayya 1977). Cuticular characters are used to help determine the affinities of taxonomically difficult taxa (Whang et.al. 2001).

However studies on cuticular ornamentation, stomata and trichome types of the genus Fagonia are little (Fahn and Shimony 1996) and (Abdel Khalik and Hassan2012); although the taxonomic value of the epidermis morphology, stomata and trichomes is well recognized in the botanical reviews for some other groups of Angiosperms such as these of (Chmielewska and Chernetskyy, 2005); (Carpenter 2006), (Ahmed et al., 2009), (Shaheen et. al., 2009), (Dmitruk and Weryszko-Chmielewska 2010), (Ahmed et al., 2010) and (Chwil, Weryszko-Chmielewska 2011) and (Osman 2012).

The present study depended on the cuticular ornamentation, types of trichomes and stomatal characters of Fagonia taxa to evaluate their significance as key characters for differentiation.

## Materials and Methods

The present study is based on specimens from the herbarium of Cairo University (CAI) and the herbarium of Botany and Microbiology Department, Faculty of Science (Girls Branch) Al-Azhar University (**Table 1).**

The stomata types were determined by stripping and fixing the lower leaf epidermis in 70% ethanol and cleared in 1% warm lactic acid before examination by light microscope **(Nassar**

**and El-sahhar, 1998)**. For the study of leaf surface (cuticular ornamentation, stomata and trichomes types) using scanning electron microscope (SEM), two leaves were mounted on metal stubs, coated, golden, examined and photographed by JEOL- SEM at the accelerating voltage of 7 and 10 Kv. The terminology of **(Metcalfe and Chalk 1979), (Barthlott 1981), (Stearn 1992) and (Munson 1995)** was followed to describe the leaf surface, stomata and trichomes.

A total of 40 comparative morphological and epidermal characters for the studied taxa were scored and coded for creating data matrix used for numerical analysis. The relationships between the studied taxa have been demonstrated as dendrograms **(Fig.6)** by using the statistical program PRIMER software, version 5.0.

**Table 1: List of studied taxa and their collection data.**

| | |
|---|---|
| 1- *Fagonia arabica* L. var. *arabica* | El Hassana-El qussiema Road-North Sinai, 11/1988.<br>El Arish, 4/1995. |
| 2- *Fagonia arabica* L. var. *viscidissima* Maire. | El Qantara East, 4/1979.<br>Wadi El-Assiuti , 10/1996. |
| 3- *Fagonia bruguieri* DC. | Red Sea Coast- Safaga hurghada road 40 km. from Hurghada, 1/1985.<br>Feiran to El-Tor, 4/ 1962.<br>El Qantara East, 4/1979. |
| 4- *Fagonia schimperi* C. | South Sinai- Wadi Arbain, 4/1984.<br>G. Musa, 4/1962. |
| 5- *Fagonia indica* Burm. var. *schweinfurthii* Hadidiin Rech. | Wadi Allagi, 1/ 1985.<br>G. Katherina, 4/1962.<br>El-Arish, 4/1995. |
| 6- *Fagonia taeckholmiana* Hadidi. | Galala desert 1980. |
| 7- *Fagonia glutinosa* Delile. | El Hassana-El qussiema Road-North Sinai, 11/1988.<br>W. Khaboba, 4/1962. |
| 8- *Fagonia mollis* Delile. var. *hispida* Zohary. | South Sinai- Wadi Arbain, 4/1985. |
| 9- *Fagonia latifolia* Delile. | Wadi El Nassuri- Wadi Angabiya along Cairo Sues Road, 3/1956.<br>Wadi Mawaw, Expedition to the Gebel Elba District, 3/ 1962. |
| 10- *Fagonia isotricha* Murb. | Wadi Mawaw, 9/1965. |
| 11- *Fagonia cretica* L. | Wadi Habis, West Mersa Matruh, 4/1980.<br>W. Khaboba, 4/ 1962. |
| 12- *Fagonia scabra* Forssk. | Galala Desert, Wadi Hamate, an affluent of Wadi Hof, 3/1988.<br>W. Um mitla, 4/1959.<br>Wadi El-Assiuti, 3/1995. |
| 13- *Fagonia tenuifolia* Steud. & Hochst. | Galala desert 1980. |

## RESULTS And Discussion

Microcharacters of taxonomic significance obtained from selected features of the leaf surfaces, using scanning electron microscope (SEM) are presented in (**Tables 2 and 3**).

**Trichomes: Table (2) and Figures (1, 2 and 3)**

The taxonomic value of trichomes in angiosperm is well recognized in botanical literature by (**Theobald *et. al.*, 1979); (Abu-Assab and Cantino 1987), (Batterman and lammers 2004)** and **(Mohamed *et.al*., 2006).**

The studied taxa exhibit great variation of trichome types, about 27 different trichomes,18 glandular, 8 non-glandular and one with special structure. *Fagonia taeckholmiana* is free from glandular trichome, while *F. arabica* var. *viscidissima* is free from non-glandular trichome and has special trichome. However five taxa (*F. glutinosa , F. latifolia, F. cretica, F. scabr* and *F. tenuifolia*) have glandular trichomes only, the remainder taxa have mixed trichomes. Some of the examined taxa had one specific glandular trichomes as unicellular with long stalk and unicellular head specially for *F. arabica* var. *viscidissima*, unicellular stalk and spinose unicellular head for *F. cretica,* multicellular basal cell; long, broad unicellular stalk and multicelluler head for *F.glutinosa.* Long, broad multicellular, multiseriate stalk and long, broad unicellular head being present only in *F. tenuifolia.* The taxa of *F.indica* var. *schweinfurthii* has two special glandular trichome (multicellular basal cell; long, broad unicellular stalk and unicelluler head and multicellular, multiseriate basal cell; long unicellular stalk and swollen unicellular head). Two studied taxa have one non-glandular specific trichomes which are unicellular papillose with curved apex for *F. arabica* var. a*rabica* and simple with long broad, acute apical cell for *F. isotricha.* The taxa of *F. bruguieri* have three specific glandular and two non-glandular trichomes which are short multicellular stalk and multicelluler head, long multicellular, multiseriate stalk and capitates multicelluler head, multicellular, multiseriate stalk and long spathulate head, unicelluler long broad clup shaped and multicellular, multiserate basal cell and long broad clup shaped apical cell. Two glandular trichomes (multicellular, multiseriate stalk and multicelluler head and long multicellular, multiseriate stalk and unicellular acute head), with one non-glandular (multicellular long broad and obtuse apical cell) are recorded only in *F. mollis* v*ar. hispida*.

The following types of trichomes have been recorded on the leaves of the studied taxa:

**A-Glandular: Figures (1and 2).**

1-Unicellular with short stalk and unicellular head.
2- Unicellular with long stalk and unicellular head.
3-Unicellular stalk and spinose unicellular head.
4-Unicellular stalk and multicelluler head.
5-Long, broad unicellular stalk and multicellular head.
6-Very long, broad unicellular stalk and multicellular head.
7-Long unicellular stalk and tetracelluler head.
8-Bicellular –biseriate stalk and multicellular head.
9- Short multicellular stalk and multicelluler head.
10-Long multicellular, multiseriate stalk and capitates multicelluler head.
11-Multicellular, multiseriate stalk and long spathulate head.
12-Multicellular basal cell; long, broad unicellular stalk and unicelluler head.
13-Multicellular, multiseriate basal cell; long unicellular stalk and swollen unicellular head.
14-Multicellular basal cell; long, broad unicellular stalk and multicelluler head.
15- Long, broad multicellular, multiseriate stalk and long, broad unicellular head.
16- Long, broad multicellular, multiseriate stalk and long multicelluler head.
17- Multicellular, multiseriate stalk and multicelluler head.
18- Long multicellular, multiseriate stalk and unicellular acute head.

**B-Non-glandular: Figures; 3 (p-v).**

1- Unicellular papillose with curved apex.
2- Unicellular spherical cell papillose.
3- Unicellular conical cell papillose.
4- Simple with long broad, acute apical cell.
5- Multicellular long broad and obtuse apical cell.
6- Unicelluler long broad clup shaped.
7- Multicellular, multiserate basal cell and long broad clup shaped apical cell.
8- Multicellular multiserate basal cell and long unicelluler apical cell.

**C-Special structure: Figures; 3 (w).**

1-Cup-shaped trichomes.

**Trichome Ornamentation: Table (2)**

Three types of trichome ornamentation have been recorded in this study; smooth in Fagonia mollis. var. hispida and Fagonia isotricha, papillose appendages in Fagonia cretica and warty in the remainders.

**Stomatal characters : Table (3) and Figures (4 and 5).**

The type of stomata is anonocytic with four to five cells, or five to six cells. Stomata levelling ranged between superficial, at a level, semi-depressed and depressed. It is superficial only in F. schimperi; semidepressed in F. arabica var. viscidissima and F. scabra; depressed in F. arabica. var. arabica, F. indica var. schweinfurthii, F. glutinosa and F. tenuifolia and at a level in the remainder. The shape of the stomata ranged between suborbiculate to elongate. Suborbiculate in five taxa and elongate in the remainder.

The aperture shape is either elliptic, round or ovate. Round only in F. taeckholmiana, ovate in F. arabica var. viscidissima and F. bruguieri and elliptic in the remainder. The width of stomatal aperture range from narrow to wide. Stomatal rim is flate in F. tenuifolia and raised in the remainder. Peristomatal rim present in two sides in F. indica var. schweinfurthii and F. cretica, while present around the stomata in F. taeckholmiana, F. latifolia and F.isotricha and absent in the remainder.

**Cuticular and wax ornamentation: Table (3) and Figures (4 and 5).**

The cuticular ornamentation favulariate is considered as the basic type, but it is straiated in three taxa, while wrinkled in F. tenuifolia only. The following cuticular patterns on the adaxial surface of the leaf are recorded.

**A. Favulariate**

Favulariate covered with smooth glossy wax. eg. Fagonia arabica var. arabica

Favulariate covered with finely warty wax. eg. Fagonia schimperi

Favulariate smooth plane. eg. Fagonia mollis var. hispida

Favulariate plane covered with finely warty wax. eg. Fagonia indica var. schweinfurthii

**B- Striate**

Slightly striated. eg. Fagonia taeckholmiana.

Irregularly striated. eg. Fagonia isotricha.

**C. Wrinkled**

7. Wrinkled with warty-crustose wax particles. eg. Fagonia tenuifolia

**THE KEY:** The studied characters were used in the construction of an indented key to the assorted taxa.

A- Cuticular ornamentation wrinkled and stomatal rim flat …….. Fagonia tenuifolia

AA- Cuticular ornamentation striated or favulariate and stomatal rim raised

B- Cuticular ornamentation striated

C- Glandular trichomes absent, stomata suborbiculate and stomatal aperture round ……..……..…. F. taeckholmiana

CC- Glandular trichomes present, stomata elongate and stomatal aperture elliptic.

D- Glandular with Long, broad multicellular, multiseriate stalk and long, broad unicellular head present and trichome ornamentation warty……. F. latifolia.

DD- Simple with long broad, acute apical cell present and trichome ornamentation smooth ……..….. F. isotricha

BB- Cuticular ornamentation favulariate or favulariate plane

E- Cuticular ornamentation favulariate plane

F-Peristomatal rim present

G- Glandular with multicellular basal cell, long broad unicellular stalk and multicellular head present, trichome ornamentation warty, Stomata depressed and stomatal aperture wide ..... F. indica. var. schweinfurthii

GG- Trichome above absent, trichome ornamentation papillose, stomata at alevel and stomatal aperture narrow……..…… F. cretica

FF- Peristomatal rim absent

H- Non glandular trichomes present, trichome ornamentation smooth and stomata at a level……..…….. F. mollis var. hispida

HH- Non glandular trichomes absent, trichome ornamentation warty and stomatal level depressed …..... F. glutinosa

EE- Cuticular ornamentation favulariate

I-Stomata ovate

J- Special trichome present and stomata semidepresed…….…… F. arabica var. viscidissima

JJ- Special trichome absent and stomata at a level…….. …...F. bruguieri

II-Stomata elliptic

K- Non glandular trichomes present and stomata outline suborbiculate

L- Unicellular papillose with curved apex trichome present and stomata depressed……F. arabica var. arabica

LL-Trichome above absent and stomata superficial……..…… F. schimperi

KK- Non glandular trichomes absent and stomata outline elongate……..…… F. scabra

**Numerical analysis: Table (4 and 5)**

All characters from epidermal structure of 13 taxa of Fagonia used were for numerical analysis by using the method of clustering as a tool in the identification of the studied taxa and in taxonomic relationships among Fagonia taxa.

The results of clustering particularly analysed by the agglomeration of Schedule measure distance, using average linkage between groups (Fig.6) showed that taxa were grouped into two major clusters, the first one (I) consisted of five taxa; Fagonia isotricha, Fagonia latifolia, Fagonia tenuifolia, Fagonia mollis var. hispida and Fagonia cretica; while the second cluster (II) comprises the remainder. The second cluster divided into two groups: group "G1" incorporated three taxa; Fagonia taeckholmiana, Fagonia arabica var. viscidissima, and Fagonia bruguieri. The group "G2" incorporated the remainder five taxa; Fagonia glutinosa, Fagonia indica var. schweinfurthii, Fagonia schimperi, Fagonia scabra and Fagonia arabica var. arabica

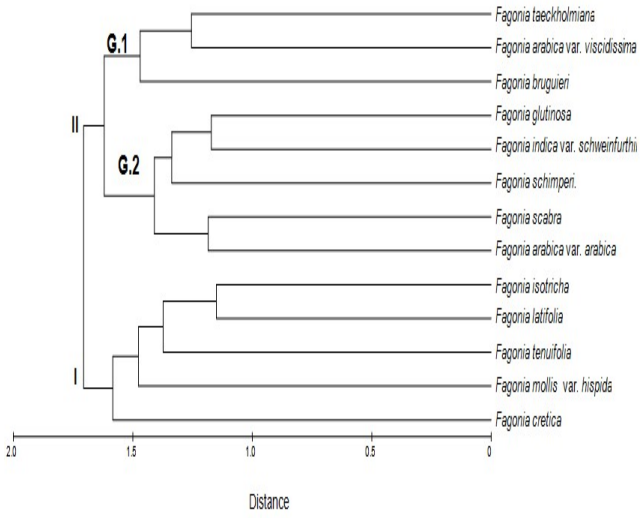


**Fig.6**: Dendrogram showing the interrelationships between 13 taxa of Fagonia based on 40 characters of morphological and epidermal features by using PRIMER Program.

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**Table 2 : Trichomes of studied taxa**

| Character \ taxa | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Glandular | 1 | + | - | + | + | + | - | - | + | + | + | - | - | + |
| | 2 | - | + | - | - | - | - | - | - | - | - | - | - | - |
| | 3 | - | - | - | - | - | - | - | - | - | - | + | - | - |
| | 4 | - | - | - | - | + | - | + | - | - | - | - | - | - |
| | 5 | - | - | - | - | + | - | + | - | - | - | - | - | - |
| | 6 | + | - | - | - | - | - | - | + | - | - | - | + | - |
| | 7 | + | - | - | - | - | - | + | - | - | - | - | + | - |
| | 8 | - | - | - | - | + | - | + | - | - | - | - | + | - |
| | 9 | - | - | + | - | - | - | - | - | - | - | - | - | - |
| | 10 | - | - | + | - | - | - | - | - | - | - | - | - | - |
| | 11 | - | - | + | - | - | - | - | - | - | - | - | - | - |
| | 12 | - | - | - | - | + | - | - | - | - | - | - | - | - |
| | 13 | - | - | - | - | + | - | - | - | - | - | - | - | - |
| | 14 | - | - | - | - | - | - | + | - | - | - | - | - | - |
| | 15 | - | - | - | - | - | - | - | - | + | - | - | - | - |
| | 16 | - | - | - | - | - | - | - | + | + | - | - | - | - |
| | 17 | - | - | - | - | - | - | - | + | - | - | - | - | - |
| | 18 | - | - | - | - | - | - | - | + | - | - | - | - | - |
| Non-glandular | 1 | + | - | - | - | - | - | - | - | - | - | - | - | - |
| | 2 | + | - | - | + | - | + | - | - | - | - | - | - | - |
| | 3 | - | - | - | + | + | - | - | - | - | - | - | - | - |
| | 4 | - | - | - | - | - | - | - | - | - | + | - | - | - |
| | 5 | - | - | - | - | - | - | - | + | - | - | - | - | - |
| | 6 | - | - | + | - | - | - | - | - | - | - | - | - | - |
| | 7 | - | - | + | - | - | - | - | - | - | - | - | - | - |
| | 8 | + | - | - | - | - | - | - | - | - | + | - | - | - |
| Special | 1 | - | + | - | - | - | - | - | - | - | - | - | - | - |
| Trichome ornamentation | | W | W | W | W | W | W | W | S | W | S | P | W | W |

W= Warty S= Smooth P=Papillose

**Table 3 : Stomatal characters and Cuticular ornamentation of studied taxa**

| Characters / Taxa | Stomatal apparatus | | | | | | Cuticular ornamentation |
|---|---|---|---|---|---|---|---|
| | level | outline | aperture | | Stomatal rim | Peristomatal rim | |
| | | | shape | width | | | |
| 1 | Depresed | Suborbiculate | Elliptic | Narrow | Raised | Absent | Favulariate |
| 2 | Semidepresed | Suborbiculate | Ovate | Wide | Raised | Absent | Favulariate |
| 3 | At a level | Suborbiculate | Ovate | Wide | Raised | Absent | Favulariate |
| 4 | Superficial | Suborbiculate | Elliptic | Wide | Raised | Absent | Favulariate |
| 5 | Depresed | Elongate | Elliptic | Wide | Raised | Present | Favulariate plane |
| 6 | At a level | Suborbiculate | Round | Wide | Raised | Present | Slightly striated |
| 7 | Depresed | Elongate | Elliptic | Wide | Raised | Absent | Favulariate plane |
| 8 | At a level | Elongate | Elliptic | Wide | Raised | Absent | Favulariate plane |
| 9 | At a level | Elongate | Elliptic | Wide | Raised | Present | Irregular striated |
| 10 | At a level | Elongate | Elliptic | Wide | Raised | Present | Irregular striated |
| 11 | At a level | Elongate | Elliptic | Narrow | Raised | Present | Favulariate plane |
| 12 | Semidepresed | Elongate | Elliptic | Narrow | Raised | Absent | Favulariate |
| 13 | Depresed | Elongate | Elliptic | Narrow | Flate | Absent | Wrinkled |

| **Table 4: Characters list for the numerical analysis of the studied taxa of *Fagonia* L.** | |
|---|---|
| **Leaf morphology** | 1- Leaf organization. Trifoliate [1]/ Tri-unifoliate [2]/ Unifoliate [3]. |
| | 2- Leaf length. Less than 10 mm. [1]/ 10 -20-mm. [2]/ More than 20 mm. [3]. |
| | 3- Petiole length. Less than 2 mm. [1]/ 2-5 mm. [2]/ more than 5 mm. [3]. |
| | 4- Leaflet shape. Elliptic lanceolate [1]/ Oblong [2]/ Obovate [3]/ Linear [4]. |
| | 5- Spine. Present [1]/ absent [2]. |
| **Trichomes** | 6- Unicellular stalk and unicellular head. Present [1]/ absent [2]. |
| | 7- Unicellular stalk and unicellular head. Present [1]/ absent [2]. |
| | 8- Unicellular stalk and spinose unicellular head. Present [1]/ absent [2]. |
| | 9- Unicellular stalk and multicelluler head. Present [1]/ absent [2]. |
| | 10- Long, broad unicellular stalk and multicellular head. Present [1]/ absent [2]. |
| | 11- Very long, broad unicellular stalk and multicellular head. Present [1]/ absent [2]. |
| | 12- Long unicellular stalk and tetracelluler head. Present [1]/ absent [2]. |
| | 13- Bicellular –biseriate stalk and multicellular head. Present [1]/ absent [2]. |
| | 14- Short multicellular stalk and multicelluler head. Present [1]/ absent [2]. |
| | 15- Long multicellular, multiseriate stalk and capitates multicelluler head. Present [1]/ absent [2]. |
| | 16- Multicellular, multiseriate stalk and long spathulate head. Present [1]/ absent [2]. |
| | 17- Multicellular basal cell; long, broad unicellular stalk and unicelluler head. Present [1]/ absent [2]. |
| | 18- Multicellular, multiseriate basal cell; long unicellular stalk and swollen unicellular head. Present [1]/ absent [2]. |
| | 19- Multicellular basal cell; long, broad unicellular stalk and multicelluler head. Present [1]/ absent [2]. |
| | 20- Long, broad multicellular, multiseriate stalk and long, broad unicellular head. Present [1]/ absent [2]. |
| | 21- Long, broad multicellular, multiseriate stalk and long multicelluler head. Present [1]/ absent [2]. |
| | 22- Multicellular, multiseriate stalk and multicelluler head. Present [1]/ absent [2]. |
| | 23- Long multicellular, multiseriate stalk and unicellular acute head. Present [1]/ absent [2]. |
| | 24- Unicellular papillose with curved apex. Present [1]/ absent [2]. |
| | 25- Unicellular spherical cell papillose. Present [1]/ absent [2]. |
| | 26- Unicellular conical cell papillose. (Present [1]/ absent [2]. |
| | 27- Simple with long broad, acute apical cell. Present [1]/ absent [2]. |
| | 28- Multicellular long broad and obtuse apical cell. Present [1]/ absent [2]. |
| | 29- Unicelluler long broad clup shaped. Present [1]/ absent [2]. |
| | 30- Multicellular, multiserate basal cell and long broad clup shaped apical cell. Present [1]/ absent [2]. |
| | 31- Multicellular multiserate basal cell and long unicelluler apical cell. Present [1]/ absent [2]. |
| | 32-Cup-shaped trichomes. Present [1]/ absent [2]. |
| **Trichome ornamentation** | 33- Warty [1]/ Smooth [2]/ Papillose [3]. |
| **Stomatal apparatus** | 34- **level:** At a level [1]/ Semidepresed [2]/ Depresed [3]\ Superficial [4]. |
| | 35- **Outline:** Elongate [1]/ Suborbiculate [2]. |
| | 36- **Aperture shape:** Elliptic [1]/ Ovate [2]/ Round [3]. |
| | 37- **Aperture width:** Narrow [1]/ Wide [2]. |
| | 38- **Stomatal rim:** Raised [1]/ Flate [2]. |
| | 39- **Peristomatal rim:** Present [1]/ absent [2]. |
| **Cuticular ornamentation** | 40- Favulariate [1]/ Striated [2]/ Wrinkled [3]. |

**Table 5: Data matrix of morphological and epidermal characters listed in table 4.**

| Characters \ Taxa | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 2 |
| 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 3 |
| 4 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 1 | 1 | 4 |
| 5 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 |
| 7 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| 9 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 11 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 |
| 12 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 |
| 13 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 |
| 14 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 15 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 16 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 17 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 18 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 19 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 20 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| 21 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 |
| 22 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| 23 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| 24 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 25 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 26 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 27 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 28 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| 29 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 30 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 31 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 32 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 33 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 3 | 1 | 1 |
| 34 | 3 | 2 | 1 | 4 | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 3 |
| 35 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 36 | 1 | 2 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 37 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| 38 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 39 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| 40 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 3 |

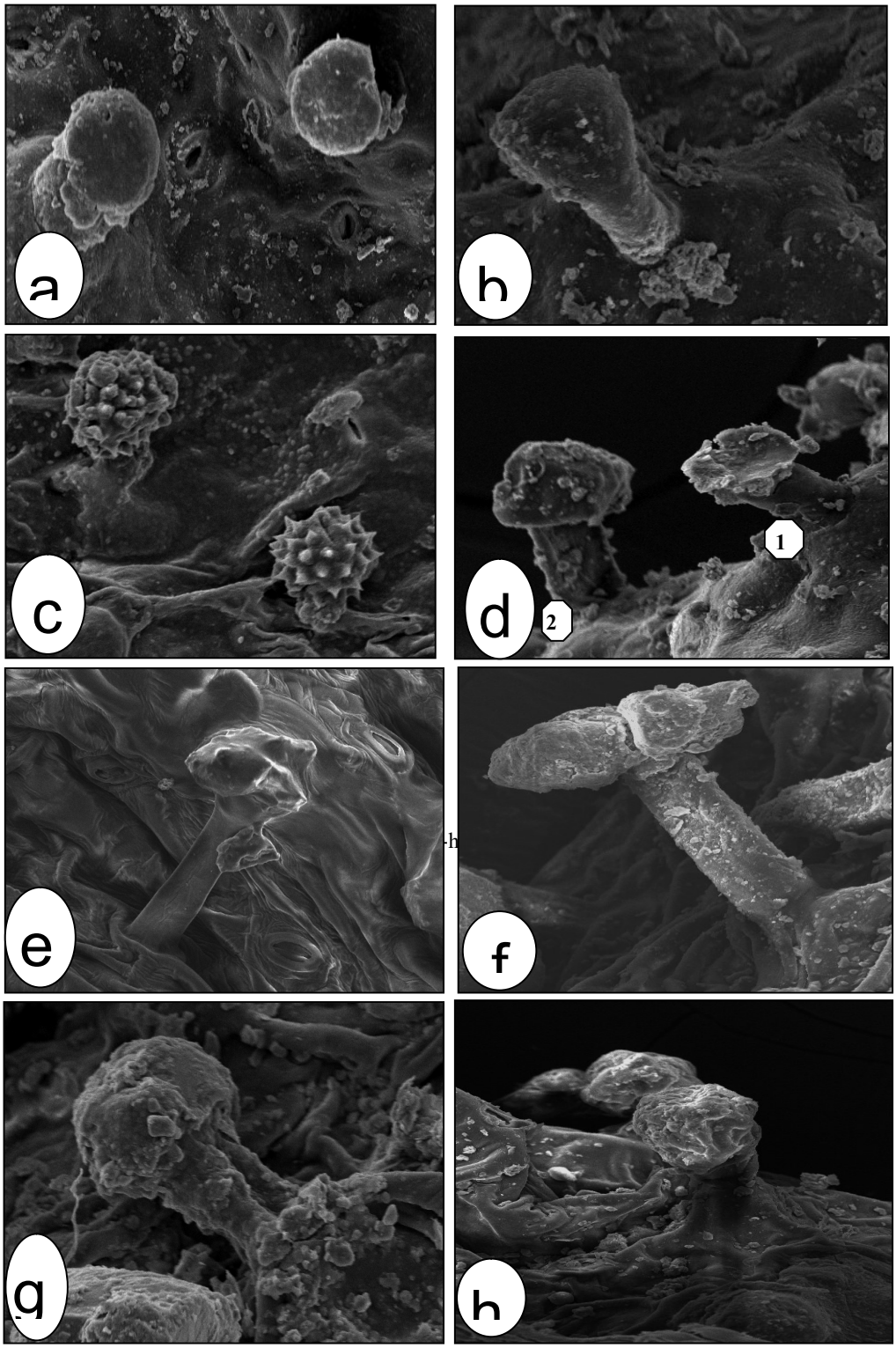


Figure 1 (a-h):Glandular trichomes

a- *Fagonia arabica* var. *arabica*
b- *F. arabica* var. *viscidissima*
c- *F. cretica*
d- *F. indica* var. *schweinfurthii*
e- *F. mollis* var. *hispida*
f&g- *F. glutinosa*
*h- F. bruguieri*

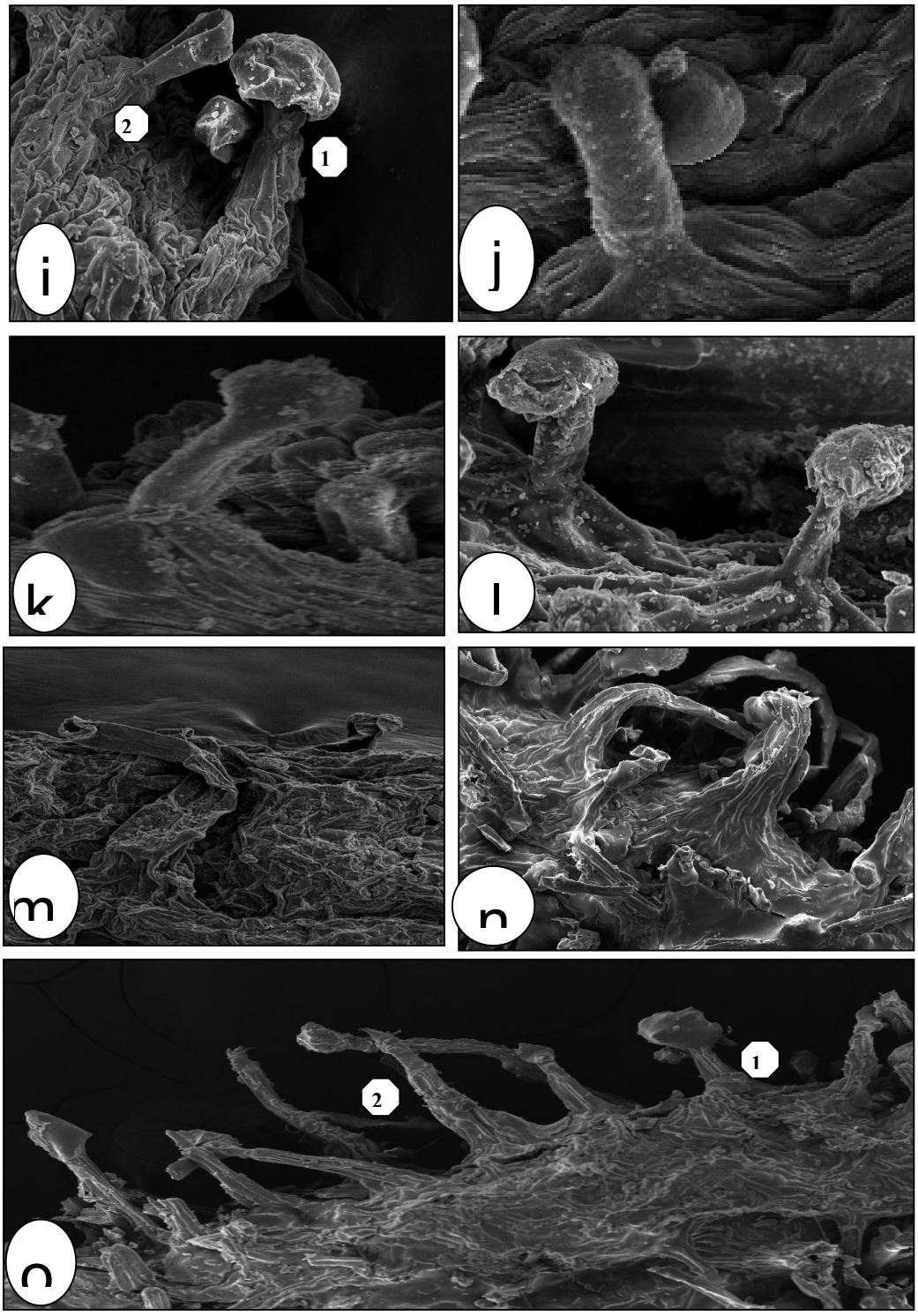


Figure 2 (i-o).:Glandular trichome

i- *F. bruguieri*
J and k- *F. indica* var. *schweinfurthii*
l- *F. glutinosa*
m, n and o- *F. mollis* var. *hispida*

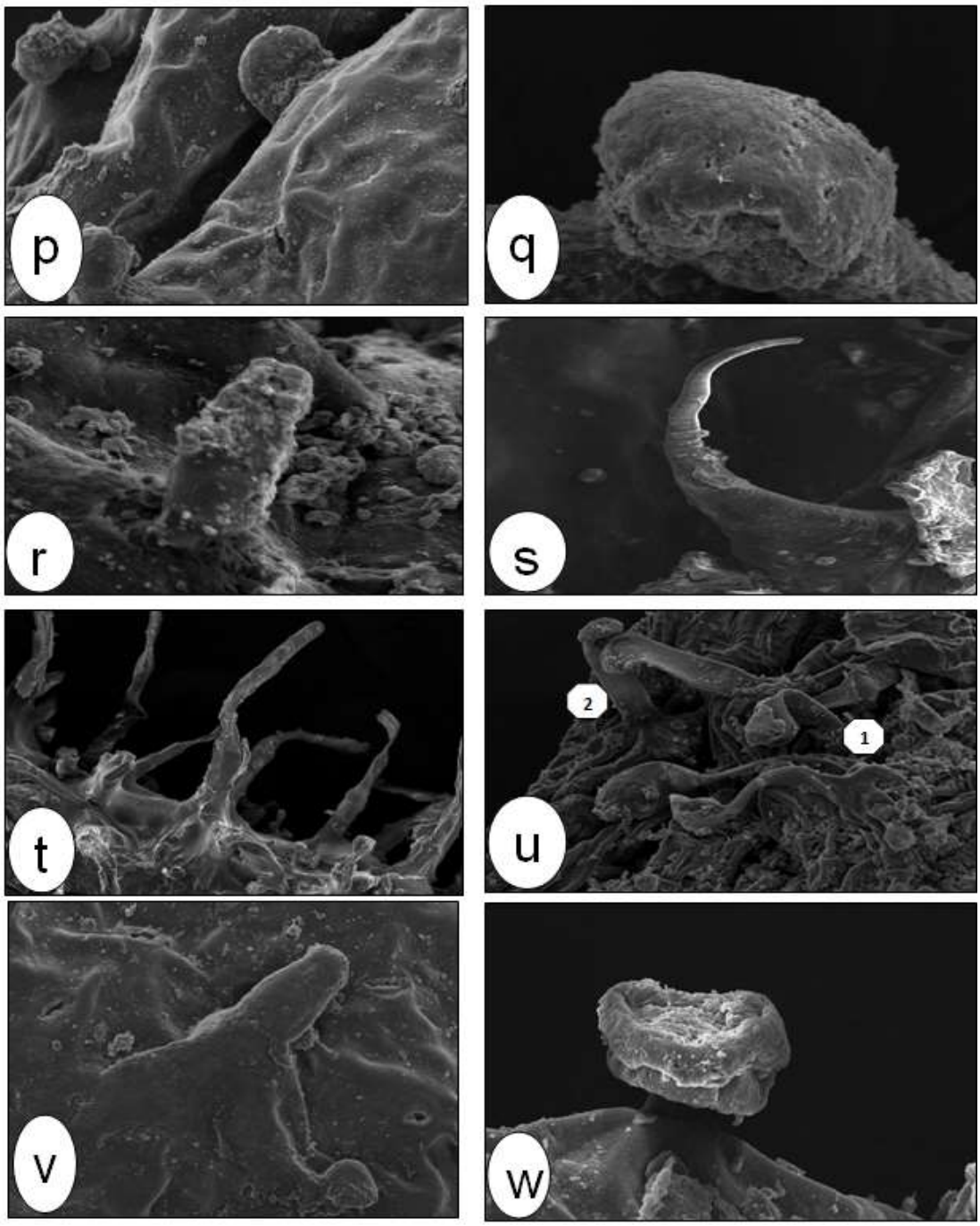


Figure 3 (p-v).:Non glandular trichome; (w): special trichome.

p,q and v- *Fagonia arabica* var. *arabica*
r- *F. indica* var. *schweinfurthii*
s- *F. isotricha*
t- *F. mollis* var. *hispida*
u- *F. bruguieri*
w - *F. arabica* var. *viscidissima*

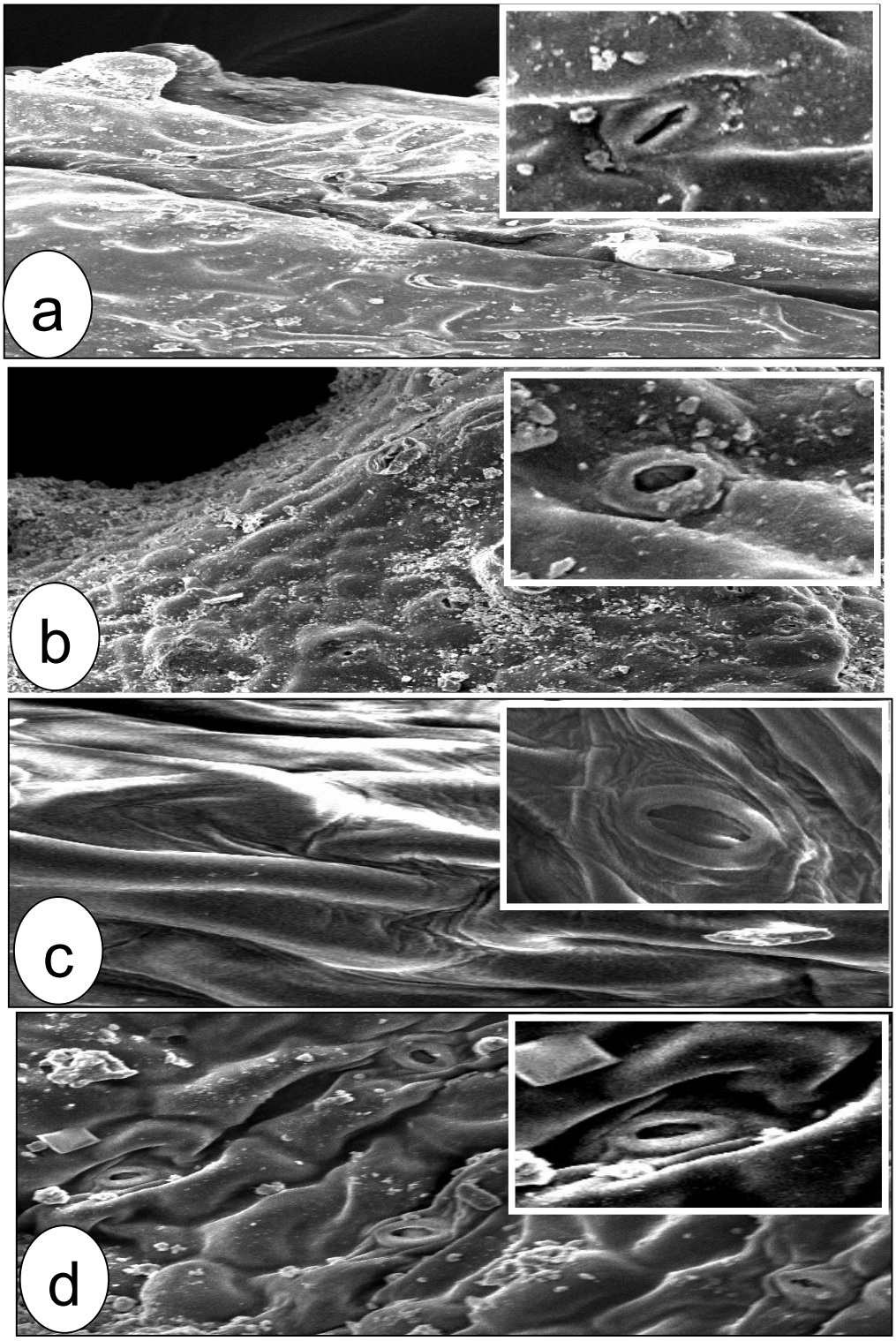


Figure 4 (a-d): cuticular ornamentation and stomatal features.

a- *Fagonia arabica* var. *arabica*
b- *F. schimperi*
c- *F. mollis* var. *hispida*
d- *F. indica* var. *schweinfurthii*

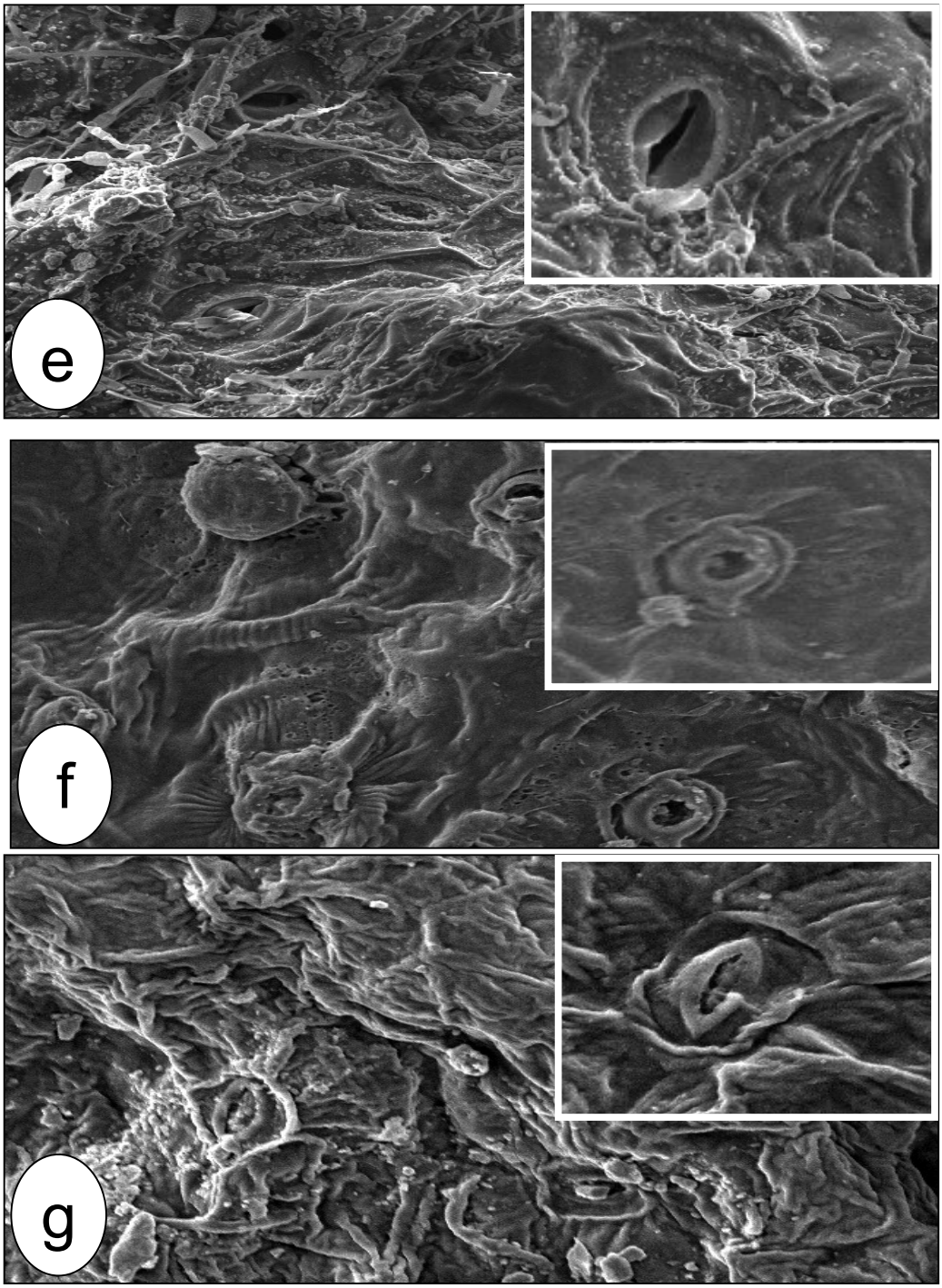


Figure 5 (e-g): cuticular ornamentation and stomatal features.

a- *F. tenuifolia*
b- *F. taeckholmiana*
c- *F. isotricha*

# الملخص العربى

## دراسة سطح الورقة في بعض وحدات نبات الشويكة (الفاجونيا) المصرية بإستخدام الميكروسكوب الإلكتروني الماسح

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تناول هذا البحث دراسة الخصائص التركيبية لسطح الورقة وزخرفة الكيوتين وانواع الشعيرات و الثغور لثلاثة عشر وحدة تصنيفية تابعة لجنس الفاجونيا المصرية باستخدام المجهر الضوئي و المجهر الألكتروني الماسح بهدف التوصل الي طريقة دقيقة للفصل بينها.

وأظهرت أنواع الشعيرات وخلايا البشرة و الثغور وزخارف السطح العديد من سمات البشرة المهمة والتي لم تسجل من قبل بهذا الجنس. وسجلت الوحدات شعيرات غدية ولاغدية وشعيرة ذات تركيب خاص بجانب ثلاث طرز من زخارف السطح هي: مجعد ومخطط ونقري. وقد أمكن التوصل الى بناء مفتاح اصطناعى للفصل بين هذه الوحدات التصنيفية.